GOOD AVIATION PRACTICE

Mountain Flying

CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

Mountain Flying

Contents

No matter where you fly in New Zealand, at some stage your flight will be affected by the mountainous terrain that makes up over half of this country. When flying in this type of terrain, the forces of nature exert a greater influence, and pilots who operate regularly among the mountains have developed a special set of skills, knowledge, and flying techniques to help them survive.

These skills are applicable whether you are among the rugged high peaks of the Southern Alps, the lower foothills, or the more rolling bush-covered terrain found in the North Island. Wherever there are ridges and valleys, be they 2000 feet or 10,000 feet amsl, the basic principles that follow will apply.

If you wish to ensure a safe and enjoyable flight in, around, or over hills or mountains you must develop these skills, collect the knowledge and appreciate the factors involved. Above all, know your own limitations and those of your aircraft – and stick to them.

Preparation

As for any flight into an unknown area, preparation is the key to a successful journey. Too many pilots venture into mountainous areas without preparing themselves properly. A healthy respect for these areas, and an understanding of their peculiarities and pitfalls, could save your life.

Weather Conditions

A good up-to-date weather briefing is essential. Weather in the mountains can change very quickly, so being aware of the big picture and looking for any trends will help. Actual weather reports are a great help, especially if you can get them from people in the area. Generally, conditions for flight in mountainous areas will be better in the morning. In the afternoon there can be more cloud build-up and stronger winds.

Terrain

The size and scale of the terrain can be difficult to appreciate. An aircraft is an insignificant dot on the landscape, and it is important to respect the power of nature by understanding the principles involved in mountain flying. Remember that you will also be a tiny speck on the surroundings when viewed by other aircraft.

Make a very careful study of charts during your pre-flight planning. Get an idea of which way the land lies so that you have an overall mental picture of the terrain before you set off. Then, should you find yourself in a situation of deteriorating weather and high cockpit workload, you will be able to answer the question, "If I cross that pass, will it take me out to lower terrain?" Passes and saddles that are used frequently have their elevation marked on the charts.

Studying the map carefully will also give you an appreciation of the steepness of glaciers and mountainsides. This can dissuade you from attempting to climb or descend through gaps in cloud cover. The slope of valley floors or glaciers can be difficult to judge and is frequently underestimated. The gradient of most glaciers will exceed the climb performance of general aviation aircraft. The old topdressing adage, "don't fly up a valley you haven't previously flown down", is one you should stick to.

An ever-present danger in valleys is wires. These can be strung across any valley, and often from a ridge down to the valley floor.

Keep a sharp lookout for signs of wires, particularly the poles, whenever you are operating below the ridges.

Plan your route according to the terrain and the wind effect. Your route may not necessarily be a straight line, but will more likely follow the direction of valleys, ridges or ranges. Plan to position the aircraft to utilise up-flowing air where possible, while also being aware of right-of-way principles in considering opposite-direction traffic in a valley (see Valley Flying, page 20).

Navigation can be particularly challenging in mountainous terrain and more than one trip is needed to completely familiarise yourself with the terrain. Get some instruction on both high-level and low-level navigation.

The navigation workload in the mountains increases significantly in poor weather, and it can be very daunting to even the most experienced pilot. You can eliminate some of this stress by good pre-flight planning.

Pre-flighting the Aircraft

In addition to your normal pre-flight items, make sure all the lights are working. In areas of high traffic density, such as over the main West Coast glaciers, around Mt Cook, and in the Milford and Queenstown areas, aircraft are much easier to spot with their lights on.

Avoid carrying unnecessary payload – this will ensure you have the maximum performance available. Check that all payload is adequately secured, as turbulence in the mountains may be stronger and more persistent than you are used to.

Make sure you have a clean windscreen – use vertical cleaning strokes, as this helps you avoid confusing any marks on the windscreen with wires when operating in poor visibility and at low level.

Pre-flighting the Pilot

Before you take off, set your limits.

What visibility limits will you place on yourself? What cloud base limits? What wind strength and direction limits? What is the latest time you can depart in order to arrive in plenty of daylight? Have you completed the I'M SAFE checklist?

Do you have escape options if the weather deteriorates behind you?

Write all these down, plus any more you can think of. This way the decisions have been made before you get airborne.

Now challenge yourself to stick to these limits.

Briefing your Passengers

When planning the flight advise your passengers to bring warm clothing and wear practical footwear. It may be shorts-and-jandals weather at the departure aerodrome but you will probably be flying over some pretty inhospitable terrain – and in the unlikely event of an emergency landing, the situation could be quite different.

Carry out a normal passenger briefing on boarding, with particular attention to any aspects pertinent to flying in the mountains, eg, effects of possible turbulence – loose articles secured, seatbelts firmly fastened, location of airsick bags. Point out the location of emergency equipment, ELT and survival gear.

Flight Plan Considerations

Make sure that you have some sort of flight following and alerting system in place – this is very important when flying over unforgiving territory. Filing a VFR Flight Plan with Airways is generally the best option – this service is staffed and reliable. If you intend to rely on family or friends for this task, can you have complete confidence that they know what to do and that they will do so efficiently and quickly? Bear in mind that their performance and reaction may be affected by worry and concern – we don't always think too well under stress.

Consider how you will terminate your flight plan. Be aware of VHF communications coverage at your destination, and cellphone coverage on the ground. If planning to terminate by radio, it may be necessary to make the call before descending, due to surrounding terrain affecting VHF coverage. Once on the ground there may not be access to a telephone nearby, and cellphone coverage may be limited.

If you do terminate in the air, remember that you will no longer have the protection of an alerting service should you have a mishap on landing. At an unattended location, you might want to consider advising your expected landing time, but extending your SARTIME to allow an appropriate time to be able to terminate by phone.

Getting All the Information

Talk to the Professionals

Get some advice and some practice before you go. Don't pick just anyone though – search out the people who have the most to offer. Many who routinely operate in mountainous terrain will be more than happy to pass on some advice. They may even be able to give you some dual instruction before you go – or come along with you on the flight – but don't count on them always being available.

Always obtain an area briefing from a local instructor, including interpretation of the local weather for the day.

Know Your Aircraft and Its Limitations

Take some time to refamiliarise yourself with your aircraft's performance.

What distance over the ground does your aircraft cover in a rate-one turn? What's the distance for a steep turn? What speed and configuration do you use for reduced visibility and for a minimum radius turn? What is the best-angle-of-climb speed? Do you know the manoeuvring speed (V_A) and understand its application in potentially turbulent conditions? How is your aircraft performance and handling affected by altitude and turbulence? How is performance affected when operating at maximum-all-up-weight?

Knowing the above factors is one thing – but being able to recall and competently apply them in flight during times of high stress and workload may one day be the difference in saving your life and the lives of others. Recent practice and currency are vitally important.

Many helicopter operations will involve landings and takeoffs at unprepared sites in the mountains, where aircraft performance can be critical. Helicopter pilots must be familiar with aircraft performance limitations derived from the use of the appropriate Hover in Ground Effect (HIGE) and Hover Out of Ground Effect (HOGE) charts. Regular reference to these charts will result in a familiarity that will allow accurate interpretation with little effort.

One last run-through of aircraft speeds and emergency procedures will never be wasted time.

Conditions in the Mountains

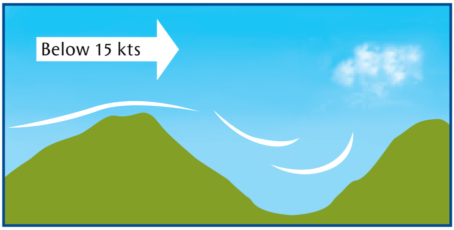
All mountainous terrain can be subject to severe and rapidly changing weather conditions. Weather is therefore a very important consideration when flying in the mountains. An understanding of at least the major airflow patterns is necessary for pilots intending only to overfly at higher altitudes.

Wind

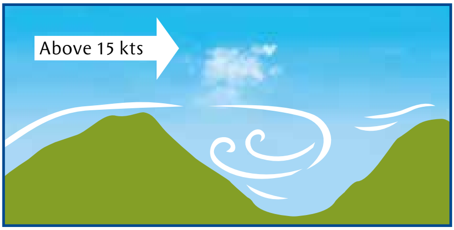
Wind of some sort is usually present in any mountainous area. Intelligent assessment of its strength and direction will help in planning flights for the probable smoothest route.

It is useful to visualise the airflow as water. (Take an opportunity to study the behaviour of water in a fast-flowing shallow stream.) Think about how water would flow over the terrain; where it would accelerate through passes, divert along valley floors before being forced over a ridge, how it would pour over ridges, and how rapids of turbulent flow would occur where flows mix or tumble over obstructions. A fluid will flow around obstacles where possible and only spills over the top when excessive volume prevents all of it from going around.

Remember that upper-level winds will not always give a clear expectation of valley winds. Other cues such as: wind effects on water, tussock or bush; or flying across valleys and perceiving drift; are ways that the valley winds can be estimated. Even observing the direction in which wild fowl take off will give a clue to the wind direction at ground level.



Below 15 knots the wind flow is generally predictable.



Above 15 knots the patterns alter and become more difficult to predict.

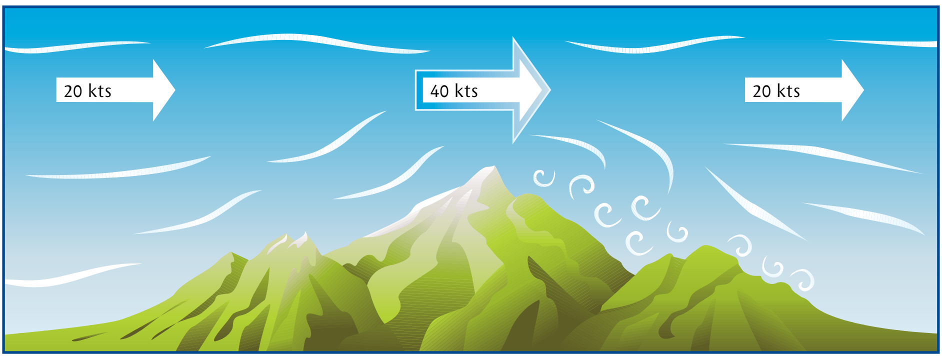
Downdraughts and turbulence will generally be found on the lee side of features and will increase in severity and extent with increase in wind strength.

Be aware of the conditions under which **katabatic** and **anabatic** winds are likely. Also consider factors such as a sea breeze or lake breeze which may energise anabatic conditions. Anabatic and katabatic winds can produce quite localised effects.

With wind above 15 knots, for an indication of valley wind, focus more on the effect of wind on water or tussock/bush, than upper cloud movement or forecast winds.

When the wind is above 15 knots, flight below the ridgelines in the lift side of the valley could be more comfortable, but flight at lower levels is unwise without the specific knowledge, training and experience that we cannot hope to cover fully here.

Flight at higher levels can give a false sense of security, so be aware that the wind is likely to be stronger with altitude, and any associated turbulence more severe.



Updraughts and Downdraughts

For pilots unfamiliar with mountain flying, the strong vertical movements on windy days can be very daunting.

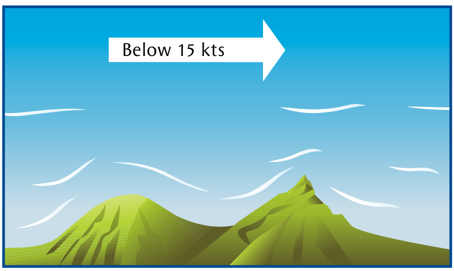
Downdraughts, which may exceed 3000 ft/min, are usually the main problem, but updraughts can also be a problem.

On the upwind side of larger mountain ranges, the air tends to be smoother and up-flowing. When you want to climb, make full use of updraughting air by assuming the best rate-of-climb configuration and staying in the updraught as long as practicable.

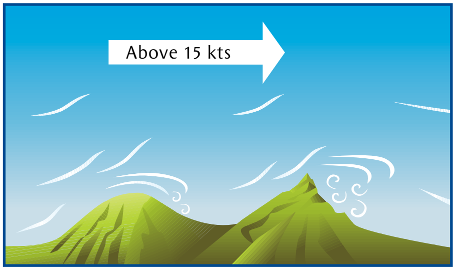
If a downdraught is encountered, turn out of the down-flowing air as soon as possible and try to locate the adjacent up-flowing air (usually by turning upwind or downwind). **Do not try to outclimb downdraughts**.

Turbulence

Any obstruction to airflow will produce mechanical turbulence. Low hills, buildings and trees will produce small-scale turbulence – mountain ranges naturally cause large-scale turbulence.



The intensity of turbulence on the lee side of obstructions varies with such factors as windspeed, the direction the air flows across the terrain, and the size and shape of the obstruction.



Large variations in wind strength and direction, known as windshear, can also have a very significant effect on flying conditions.

It is possible to experience wide airspeed fluctuations in turbulence. Maintain an aircraft **attitude** for a safe mid-range airspeed between stall speed and manoeuvring speed, and **fly attitude rather than chase airspeed**.

Remember that V_A is the speed above which any full or abrupt control movement can place excessive stress on the aircraft. So, if turbulence is present, remaining below this speed not only ensures the integrity of the aircraft but also minimises discomfort for the persons on board. Manoeuvring speed reduces with reduction in weight, so with light loads the appropriate speed will be lower. When turbulence is anticipated, keeping your hand on or near the throttle is important to enable timely responsive power changes.

For helicopter operations, while it is possible to sometimes take a hand off the flight controls for brief periods (usually the collective) during flight through turbulence, it is prudent to keep both hands lightly on the controls. Trying to fight the movement of the helicopter will only result in a more fatiguing and uncomfortable flight. Allow the aircraft to respond to wind movement while gently maintaining heading and altitude.

Before any flight in mountainous terrain, ensure all on board have their seatbelts firmly fastened. It is worth remembering that your passengers may have less tolerance for turbulence than you do – so don't overdo their exposure to any rough air. Learn to interpret their comfort level. While they are conversant and interested in the surroundings (taking photos, etc), they are within their comfort zone. When they become quiet and show no interest in what is outside the aircraft, they are likely to be very nervous, uncomfortable or nauseous. Remember that your comfort threshold is likely to be higher than your passengers. It is critical to recognise this to ensure an enjoyable flight for all.

Ensure all luggage is well restrained and any loose items secure. Turbulence can occur without warning especially if you are inexperienced in reading the signs.

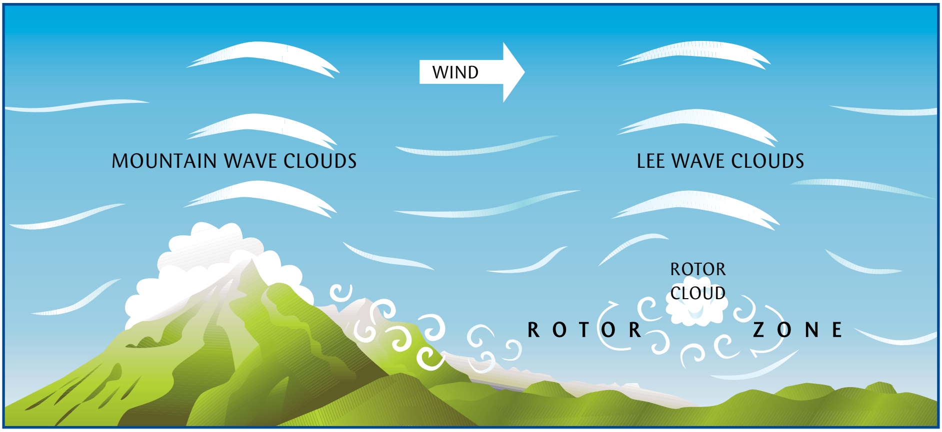
A fundamental skill to learn is to be able to interpret from cloud type and behaviour the anticipated flying conditions.

Mountain Waves

When the wind blows at or near right angles to a mountain range, or high isolated peak, the air is naturally disturbed, as it must go around or over the obstacle. Mountain waves form quite frequently when air is forced over an obstacle. There are two further conditions that must be met before mountain waves will form:

- A low-level wind of at least 15 knots, which increases in strength with height.
- A generally unstable atmosphere at low levels, with a stable layer at a higher altitude.

If the air has sufficient moisture, then the crest of these waves may form a lenticular (lens-shaped) cloud. Although these clouds appear to be stationary, in reality they are continually forming on the upwind side and dissipating on the leeward side. Generally, **smooth strong updraughts** can be found on the **windward** side of these clouds.



On the leeward side of these clouds the air is descending as quickly as the air on the windward side is rising. These descent rates may be too great for passenger comfort (and pilot peace of mind!).

If the leeward side of the lenticular cloud is ragged you can expect there to be **severe turbulence downwind** of these clouds.

When the wind becomes strong, moderate to severe turbulence will be encountered on the lee side, from the surface to well above the mountain tops. In the Southern Alps quite severe lee turbulence can be experienced several miles downwind of some peaks and considerably above their height.

Most mountain waves in New Zealand result from prevailing westerly winds, but wave systems can be encountered whenever there is sufficient wind and terrain to generate the wave disturbance. Glider pilots use this to great effect for their soaring, so if you have a gliding club near you, check with them; they will be able to explain more about lee wave systems.

Rotors

A rotor is a large closed eddy that forms in the lee of a mountain range, or any obstacle in the airflow, and is an area of severe turbulence. Rotors are usually found under the crests of mountain waves, often within 3000 feet vertically of the generating ridge. The wind below the rotor

This cloud pattern indicates potential turbulence from rotor.

will be in the reverse direction to the general flow. Updraughts and downdraughts in a rotor have been measured at over 5000 ft/min.

Rotors can sometimes be recognised by **small ragged, wispy bits of cloud** beneath a mountain wave cloud but if there is insufficient moisture for cloud formation, **rotors may be invisible**. Lines of rotor will lie perpendicular to the wind flow; ie, in a westerly flow, the rotor line will be orientated north-south.

In these conditions keep the airspeed below the maximum manoeuvring speed (V_A).

Avoid rotors where possible.

Cloud

Conditions can change rapidly, and cloud can form very quickly. A slight change in temperature towards the dew point can produce almost instant cloud. It can rapidly build up around passes and ridge-crossing points.

Cloud build-up occurs especially during winter afternoons as the temperature drops. Cloud thickens and lowers – at ECT it will be darker than it would be on a clear day.

In fine weather, thermal heating and associated cloud build-ups are common along the tops of mountain ranges and on the upwind side of the ranges. These tend to be at their maximum between 2 and 3 pm and usually die down in the late afternoon, disappearing by 6 to 7 pm.

Looking East near the head of the Waimakariri River

Beware of rapidly forming cloud.

Beware of high-level cloud lacking a defined base lowering to blend with lower-level scattered cloud. This can sometimes be difficult to detect and may trap the unwary. Northerly conditions in South Island mountain areas can produce this situation. Do not be suckered into flying between ill-defined cloud layers.

Season

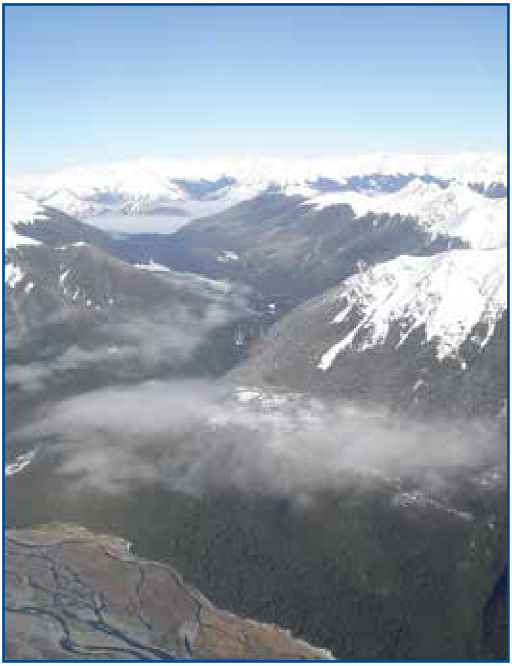
In winter there is more snow, so there is more to see in a scenic sense, but, because of the snow cover, it will be harder to identify glaciers and passes. Orientation is more difficult with total snow cover. There is less definition – ridges and passes are more uniform in appearance. Even the most familiar terrain can become unfamiliar to the most experienced mountain flying pilots.

In winter, storms are more severe, but on fine days there is less wind, less cloud and less thermal turbulence. The air is more stable, with good clear visibility, and aircraft performance is better in the cooler conditions.

Some of the best flying conditions occur in winter, especially on clear frosty days.

Changeable Weather

Because conditions can alter with subtle changes of wind strength and direction, it should be obvious that a watchful eye must be kept on the weather conditions, both at the flight planning stage and throughout the flight. Keep a close watch ahead and behind. A sudden deterioration could prove a major problem. If in doubt – back out early.



Lighting

Different lighting conditions can create definition and depth perception problems in the mountains.

This photo shows deep shadow on the left side of the valley. The wide river valley narrows and steepens towards the pass at its head.

The position of the sun can cause areas of deep shadow, especially in valleys, into which it is difficult, even impossible, to see. This can occur in the early morning or late in the day when the sun is low on the horizon, and is more marked in winter. When flying from sunlight into shadow, it may not be possible to clearly define terrain clearance.

In snow-covered areas there is flatter, harder lighting in the middle of the day, making depth perception more difficult.

Maintaining an awareness of the sun's position is also important so you are not surprised by bright light as you come around a ridge or peak. This can happen at any time when below the ridgeline, so have your avoiding action planned.

Whiteout

There is always a certain lack of definition on snow surfaces, but this worsens very quickly when sunlight becomes subdued.

> When a large unbroken expanse of snow has the direct light reduced by an overcast sky, all trace of surface texture or shadows can be hidden. Hollows and snow-covered objects merge into a flattened white background, and any gradient can be disguised. In addition, cloud and sky have the same apparent colour, so horizon discrimination is lost and the face of the ground disappears. It becomes impossible to judge height and distance. It also becomes impossible to see any patches of lower cloud.

Whiteout conditions are likely when operating over glaciers below a solid cloud ceiling. In the lower sections of the valleys there is nearly always plenty of rock, tussock or shingle to provide good terrain perception. Further up towards the head of the glacier, pilots must be alert to potential perception problems and be prepared to turn back down the valley **before** the safe visual cues start to disappear.

Contrast

An illusion of contrast occurs when dark-coloured rocks or ridges are visible above the snow. This illusion can deceive a pilot by giving the impression that good contrast conditions exist, when in fact it is still difficult to estimate the aircraft's current height above the ground. This is a real trap for helicopter pilots when preparing to land or take off and when operating at low level.

Brightout

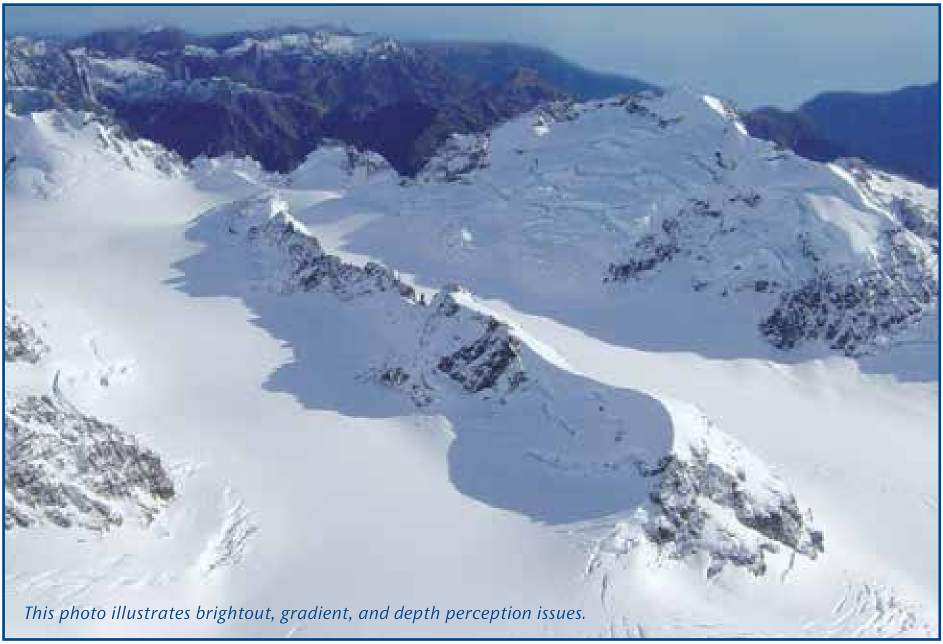
In snow-covered areas, brightout occurs with a clear sky and bright overhead sunlight conditions. No shadows are cast because of the bright reflection from the snow. This can give a false representation of what you are flying over and cause partial disorientation. There is virtually no visible definition, and as a result hummocks and ridges will appear flat on unmarked snow. Again this can be a problem for helicopter pilots operating close to the surface.

Anticipation of sudden exposure to bright sun when emerging from behind a ridge is important.

The most important principle for flying in snow areas is that you progress according to **what you can see and verify**. The worst trap is attempting to proceed because there appears to be **nothing** ahead; this is the classic feature of whiteout conditions – the seeming void ahead and below.

The worst areas are those of total snow cover, such as the upper névé areas of glaciers, and other areas immediately after heavy snowfalls.

Flight in these conditions is only safe when the pilot is familiar with the area and has sufficient reliable visual cues to determine the position of valley sides and the surface below.



This photo illustrates brightout, gradient, and depth perception issues.

Common Illusions

Relative Scale

When you are among large mountains, especially in clear air, it is very difficult to accurately judge scale and distance. Mountains seem a lot closer than they actually are, simply because they are so much larger than you are. It's hard to imagine that some of the crevasses in the major glaciers would swallow an aircraft whole, leaving no trace at all.

The most effective way to confirm your distance from the terrain is by picking out features on the surface that you can accurately judge the size of, such as tussocks, trees, or bush. This will help you work out how far away you are and give you an indication of your size relative to the mountain. It is important to be able to judge your distance from the terrain – this is the only way to know if you have allowed enough room for a reversal turn.

Sometimes, when you are in mountainous terrain in strong winds, you need to be up close to the terrain, as it could be the safest place to be, but you must always leave yourself sufficient room to turn away. You should not be venturing close to terrain without any instruction or guidance beforehand.

Hidden Obstacles

A common perception problem, of which pilots should be constantly aware, is the tendency for snow-covered faces and ridges to merge with each other. Mountain faces in the distance, with a mix of rock and snow, can very easily mask the presence of a much nearer ridgeline of rock and snow merging against the background. This can also occur with rock, bush or tussock-covered hill faces and ridges.

The classic situation is the aircraft climbing towards a mountain range a few miles away, that is slightly higher than the aircraft, and an intervening ridge of similar cover merges visually with the more

distant face. Because there is very little relative movement between the two ridgelines, and poor distance perception with featureless snow-covered terrain, the nearer one can be mistaken for part of the more distant face.

The same effect can occur when following the side of a snow-covered valley where ridgelines extend out from the main valley profile. It is very important to maintain good visual contact with the bases of approaching ridges, and with valley profiles, so that a complete picture of the terrain ahead is correctly perceived.

The situation is more pronounced in overcast or shadow, but it can still be a problem in full sunshine.

False Horizons

The frequent lack of a defined external horizon can create aircraft attitude and airspeed problems. When flying among the mountains, or anywhere the horizon is not visible, the pilot must learn to imagine that horizon. The useable horizon is the line where the sky meets the sea. In the mountains, visualise where this line is as if the mountains were transparent, and superimpose it on the terrain.

Mountain-flying training, with instructors experienced in the mountains, is necessary to recognise how essential it is to be able to identify a useable horizon and to experience some of the pitfalls involved. It is not an innate ability but a skill that must be learnt. Without this skill, it is difficult to maintain a consistent nose attitude, manoeuvring in a valley could be hazardous, and safety margins are therefore eroded. A gradual valley gradient can seduce a pilot into subtly raising the aircraft nose resulting in a potentially unnoticeable loss in airspeed and RPM – until it is too late and there is insufficient height or space to recover.

Accurate identification of a useable horizon and being able to reference nose attitude to that horizon usually requires at least five hours concentrated practice.

At higher altitudes assessment of horizon is easy, at lower altitudes less so.

Relying on your instruments alone won't work. In a confined space with reduced visibility your eyes must be outside, and performance must be interpreted by any subtle change in nose attitude and only confirmed with instruments. With reduced altitude and space the lag in instruments is too great to rely on them implicitly.
If pilots try to follow the artificial horizon, they will only ever **react** to the instruments, when they should have their eyes outside and be **anticipating** the attitude changes.

In bush-clad areas there is a good high-level horizon reference – the bush line (ie, mean winter snowline). In New Zealand the bush grows up to an altitude of around 3500 feet, and it is a good means of locating a useable horizon reference in steep mountainous terrain.

Manoeuvring adjacent to sloping terrain makes it more difficult to judge bank angles. The trap is to over-bank, which invites unwanted descent and reduction of stall margins. You must scan the necessary instruments to ensure you are achieving the bank and speed you want.

Ease into a turn, anticipating the bank required to use all the available space, tracking the nose around this imaginary horizon.

Flying Techniques

There is no substitute for practical, basic, mountain-flying training. Do not rely on what you read here to be enough.

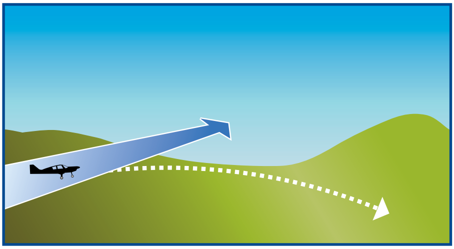
In bush-clad areas there is a good high-level horizon reference – the bush line.

Ridge Crossing

Ridge crossings are a compromise of many issues. The basic rule, however, when crossing a saddle or pass, is to cross at an angle that allows for an escape route if needed. The shallower the approach angle, the easier it is to turn away if necessary.

Learn how to assess the lift and sink sides of the ridge. If approaching from the leeward side, allow ample clearance and be alert for sink. If approaching from the windward side, updraughts should assist with clearance but beware of being carried up into cloud.

The approach here is from left to right with an escape route available to the right. There would be no escape route the other way due to the terrain on the left.

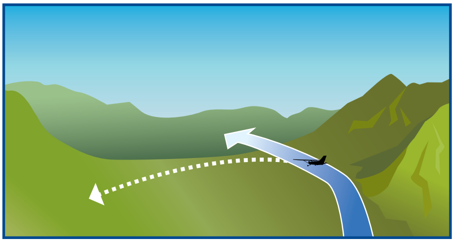


Try to approach at 45 degrees, or a shallower angle if possible, with the ridge or saddle on your left. This approach offers:

- the best view of the approach including the other side of the ridge
- a shallow approach angle and therefore shallow escape angle. In sink or turbulence you have a minimum angle of bank required to turn away, therefore less wing loading and lower stall speed.

Your escape route must be obstacle-free through a shallow angle downhill and downstream in anticipation of any sink.

If the position of a ridge or a spur denies an escape route to the right, then a right to left crossing with the ridge on your right may be necessary. **Always** have the best escape route available.



Choose a knife-edge ridge which can be crossed in minimum time rather than a flat ridge, which requires a prolonged period to cross.

Approach in level flight, with your speed under control (below V_A) and your hand on the throttle in anticipation of windshear, which, if present, will occur at the ridge crossing.

Always make sure you have adequate terrain clearance before crossing a ridge. With a constant nose attitude in level flight, if you are seeing more terrain behind a ridge, then you will clear the ridge, but make sure you have sufficient height to provide a safe margin. In windy conditions allow a greater altitude margin. If you are seeing less terrain behind a ridge, then you won't clear it; you must recognise this and turn away early to gain more height before making another attempt.

Do not approach in a climbing attitude; low speed means you have less margin above the stall, visibility over the nose is impaired and, if experiencing any sink, judgement of safe height to cross is difficult. Do not cross in a descending attitude, as high speeds can cause structural damage in turbulence, and once across the saddle your return options are limited, as height needs to be regained to return across the saddle.

Valley Flying

Normal recommended mountain-flying technique is to fly on the lift side of a valley so that the aircraft is flying in smoother updraughting air. If a 180-degree turn becomes necessary, it is then being made into wind, requiring less distance over the ground.

This 'pure' technique needs to be balanced with the recommended right-of-way practice of flying on the righthand side of a valley. This is very important in areas of high traffic density and on any commonly-used VFR route.

When operating in areas where other traffic is likely (and this applies to many common routes in New Zealand), fly on the righthand side of the valley (allowing sufficient turning space should an immediate turnback be necessary). If attitude and altitude are difficult to maintain due to sink, change to the left side, but be aware of the likelihood of meeting other aircraft, and maintain a particularly good lookout. Make frequent position reports for the benefit of other aircraft.

Bear in mind that downdraughts may be encountered on the lee side of any terrain.

Flying to one side of the valley with escape option available and checking that more terrain is showing behind the pass ahead.

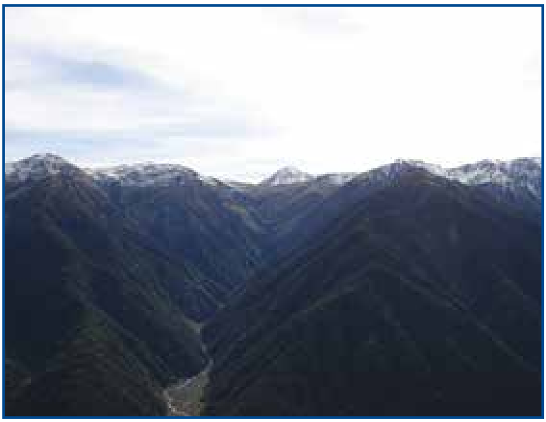
Remember that the wind strength and direction in a valley can vary markedly with height. At low level the wind may be up or down a valley, while nearer the tops of the ridges it may be across the valley.

Do not attempt to climb up or descend down a steep glacial valley beneath a cloud layer – even if you can see it is clear at the head of the glacier. There are two problems: the cloud often shelves down along the contour of the glacier; and the slope of the glacier may well exceed the performance capabilities of your aircraft.

In narrow valleys commit to one side or the other, preferably the righthand side.

Entering a Valley

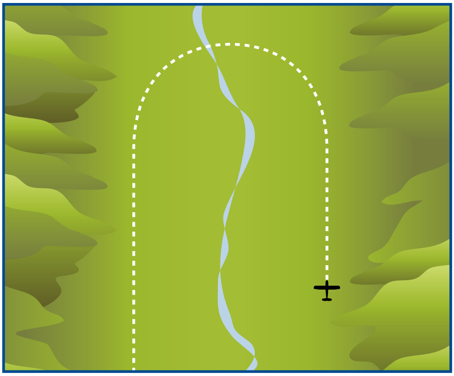
When entering a valley, always double check with the compass and map to ensure you are in the right valley. This simple check could have prevented several accidents in New Zealand where aircraft have ended up in a narrow or dead-end valley – sometimes with fatal results.



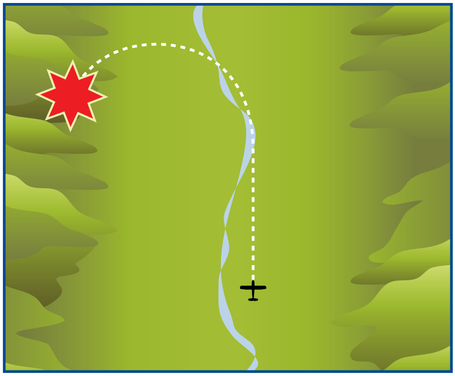
Dead-end valley

Know whether the valley climbs and what altitude you will need to clear the pass or ridge at the end. Once again, if in doubt use the old topdressing adage, "never fly up a valley you haven't previously flown down".

Flight up a valley, keeping the escape route open, may be necessary in certain circumstances to assess an unseen saddle at the head. Do not attempt this without the training and experience necessary to help make a safe plan.



Positioning to one side of the valley leaves maximum room to turn. Always use the maximum room available in case a 180-degree turn is required.



Positioning in the middle of the valley means a steeper turn is necessary and there may be insufficient room to turn back safely.

Make regular check turns to assure yourself that a safe turning radius is available.

Turning

Always position yourself in a valley so that you will have enough room to turn around if needed. You need 5 to 7.5 seconds to see, evaluate, decide and execute. If you are in sink and at low level, this time plus any time taken to move over in the valley, will be longer than you have. In narrow valleys, commit to one side or the other, preferably the righthand side for the reasons mentioned earlier. Under no circumstances position yourself in the middle of the valley – no-man's-land. The only exception to this is when you are in a large valley where turning radius is not an issue – in this case anywhere right of centre is appropriate.

Leaving maximum room to turn also means less bank angle is needed, therefore less wing loading, a lower stall speed and less pressure on the pilot. When executing the turn, control the speed; too much power translates into too much speed, which means a greater radius. Use only enough power to maintain an airspeed that allows a controlled turn with an appropriate radius.

Ease into the turn, anticipating the bank required to use all the available space, using only the power required to control the speed to maintain a safe margin above stall speed (V_S) and considering manoeuvring speed (V_A) as conditions require.

Remember that the radius of turn increases with speed and stall speed increases with angle of bank.

If the space is looking confined, make check turns of 360 degrees to ensure an escape route remains open **before** committing. Use the reduced visibility configuration to enable slower speed and smaller turn radius.

During the lookout before the turn, remember to superimpose an imaginary horizon line onto the background.

Downsteam leads to bigger rivers, lakes, roads and towns.

If, when in the turn, airspeed decays with full power applied, lower the nose to convert height to airspeed.

At maximum-all-up-weight the aircraft will not perform as well as when lightly loaded, turn radius will be greater, and rate of climb is reduced. Many accidents occur because of a stall in the turn or because the pilot attempted to out-climb terrain. Both are directly linked to poor horizon recognition.

Escape Routes

The golden rule of mountain flying is to **always have an escape route** regardless of whether you are flying a fixed-wing aircraft or a helicopter. The aircraft must never be placed in a situation where there is insufficient room to turn back safely, or to recover from an encounter with turbulence or downdraught, or to make a successful forced landing in the event of an engine failure.

Never enter a narrow valley without being certain that there is an escape route available.

If disoriented, remember that downstream leads to bigger rivers, lakes, roads and towns where such features assist in re-orientation. Always be aware of which way a stream or river runs. Significant white water in a stream or river indicates a steep gradient.

Remember Murphy's Law of mountain flying: when you need to turn back, it will be through sink, turbulence and a tailwind – so make sure you have the space and height available to do it safely. Don't rely on aircraft performance to get you out of trouble – good anticipation and good decisions are required.

Altitude

Density Altitude and Aircraft Performance

One aspect of mountain flying that requires particular attention is aircraft performance. A pilot must keep in mind, when considering the performance characteristics of the aircraft, that density altitude is a critical factor. Aircraft performance depends on air density, which directly affects lift and drag, engine power and propeller or rotor efficiency. As air density decreases, aircraft performance decreases.

Low atmospheric pressure, high temperature, and high humidity all result in a decrease in air density and an increase in density altitude. Density altitude represents the combined effect of pressure altitude and temperature. Most navigation computers will work out density altitude. Practise these computations often until they become second nature so that, for any flight into higher terrain, you can be assured of accuracy at very short notice.

Aircraft performance, especially climb performance, is reduced with increasing altitude. Avoid placing your aircraft in a situation where the power margin, while adequate at low altitude, is insufficient at a higher altitude.

A lightly-loaded aircraft is best, but be sure to carry sufficient fuel for unplanned diversions – the terrain is generally uninviting for a forced landing.

Helicopters

Density altitude increases will have a very marked effect on helicopter performance, as follows:

- Control effectiveness reduces with increasing density altitude. This will become apparent with a sluggishness in the controls.
- For a given indicated airspeed, the true airspeed (TAS) and therefore inertia, is higher. As the air is less dense, rotor response will be slower. Cyclic movements will be larger and rotor disc response slower when operating at higher altitudes.
- To achieve the total rotor thrust required for flight, collective pitch settings will increase with increasing density altitude. Ultimately less collective will be available to control a descent, and autorotation performance is also degraded.

- The tail rotor also requires an increase in pitch to counter torque and will be less efficient with an increase in density altitude.
- In general, a great deal more precision with control inputs will be required to operate the helicopter at its maximum capability.
- The helicopter will be more susceptible to retreating blade stall due to the increase in blade pitch on the main rotor.
- As the TAS increases with the increasing density altitude, the turning radius will increase when a constant indicated airspeed (IAS) is maintained.
- The rotor rpm in autorotation is higher at higher density altitudes. Therefore, more collective is required to control rotor rpm in autorotation and less is available on touchdown.
- Helicopters, by nature of their versatility, are commonly used for landing and taking off in mountainous areas. As the rotor is less efficient at higher density altitude, the power required will increase and this, combined with reduced engine power (particularly normally-aspirated piston engines), can cause serious performance degradation. Pilots flying in the mountains and at higher altitudes need to be intimately familiar with the various performance charts in the "Limitations" section and also the "Supplements" section of the Aircraft Flight Manual. Performance calculations often need to be conducted in flight and often at short notice. A well-prepared pilot will be familiar with the use of the performance charts and (as with the pressure altitude vs density altitude calculations) the use of these charts should become second nature. If you are not a regular flyer into the mountains, give yourself plenty of time to prepare for the flight and accurately apply the data in the performance charts.

The constraints of surrounding terrain may dictate non-standard approach patterns but may also influence conditions of windshear, crosswind, sink, lift, etc.

Approach and Landing

Always join overhead a strange aerodrome to check for runway layout, wind, traffic and terrain. With mountain airstrips, the constraints of the surrounding terrain will dictate how this is best done. Follow as close to a standard pattern as possible, although a precise circuit pattern may not be practicable. Make sure you know the elevation of the place you are going to land. Aircraft performance on higher mountain strips is markedly reduced, especially in summer. Ensure you have sufficient landing and takeoff distance available.

During spring, identification markers of strip dimensions (tyres, marker boards, etc) can be disguised by long grass that also causes considerable drag. In some areas in winter, surface conditions can be very 'heavy' due to soft muddy surface conditions with associated poor braking. Some **frozen** surfaces can be very rough – frozen horse or cow manure and vehicle ruts are **very** dangerous. A careful observant inspection run of the surface is important, as the condition can differ from day to day. An enthusiastic rabbit needs very little time to dig a new hole!

An approach and landing at altitude requires accurate control of airspeed and rate of descent. Use the same speeds as you would for a landing at lower altitudes. If the conditions are gusty add a **small** amount to the approach speed (a good rule-of-thumb is to add half the gust factor to 1.3 V_s). The true airspeed and groundspeed will be higher because of the density altitude. The higher groundspeed will also lead to the glideslope being flatter when holding a 500 ft/min descent rate. Use full flap and be prepared to apply full power and raise the drag flap if you need to go around. If you are approaching a one-way strip, have a go-around point for an angled escape decided well out from the strip.

It is not unusual for pilots to find themselves approaching the intended landing site with an excess of altitude. This may occur for a number of reasons:

- in confined spaces a natural tendency is to hold altitude to have a greater sense of space;
- the location of the landing area in relation to surrounding rising terrain;
- the desire to extend the distance seen ahead; or
- simple failure to recognise identifiable landmarks near the landing site.

Take care not to end up 'hot and high' – lowering the nose and developing a high rate of descent and/or excessive speed will prevent a good accurate landing.

If runway slope and surrounding terrain are significant factors, land uphill. If you are doing a touch-and-go, do so downhill.

Always have a clearly defined decision point where you can go around if you are not happy that a safe landing is achievable. This equally applies whether you are flying an aeroplane or a helicopter.

On final approach to an aerodrome with an up-slope, a visual illusion occurs because the pilot's eye interprets the up-sloping ground as level. This illusion fools the pilot into believing that, relative to the touchdown point, they are higher than they actually are and that the attitude is more nose-down. To compensate for this, it is common for pilots to fly lower and slower than necessary.

Uneven terrain around an aerodrome can make it difficult to correctly judge the nose attitude when relying entirely on visual cues. Because of this and any potential visual illusions, the airspeed indicator needs to be monitored throughout the approach while maintaining a wider visual scan than normal, taking into account the surrounding terrain.

A bad approach will rarely end in a good landing. Because power is adversely affected by altitude (acceleration is slower) when it is needed it should be applied as early as possible. Set yourself up so that the go-around decision can be made early.

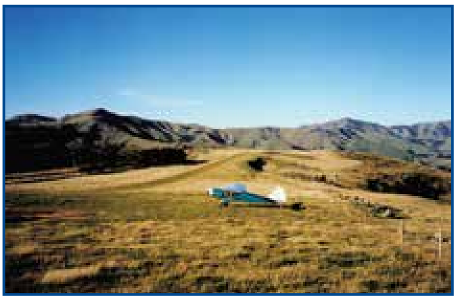
Avoid an approach profile that takes you below the touch-down point. When landing uphill the flare needs to be exaggerated. The aircraft needs to be flared beyond a level attitude to contact the up-slope at the correct angle.

Takeoff

At high-altitude aerodromes, density altitude factors must be considered. Even when the aerodrome is not at a high altitude, the nature of the surrounding terrain can mean that the aircraft should be flown to its maximum available performance until a safe altitude and position is reached.

Full power should be maintained after takeoff until a safe height and distance from terrain is reached.

When taking off from a down-sloping strip, rotate only to a level attitude; remember that you are travelling downhill and if you



rotate to what would be the normal position on a flat runway the aircraft could stall.

Always have a 'go/no-go' decision point approximately one third along the strip so that, if aborting the takeoff, the throttle is closed and appropriate braking has commenced before the half-way point.

For helicopter pilots, it is crucial that you are familiar with the performance charts applicable to your helicopter. Be sure to consult any performance charts associated with modifications to the helicopter that may affect aircraft performance (found in the "Supplement" section of the Aircraft Flight Manual).

Human Performance

Workload

A high cockpit workload, resulting from the requirement for greater than normal navigational accuracy and a constant lookout for other aircraft, can result in reduced mental capacity to make decisions and handle new tasks or problems.

To pilots who are inexperienced in mountain flying, the physical and mental stresses can be severe, and they may steadily erode the capacity for sound judgement and action. Thus, when the destination is reached, the pilot's ability to cope with problems is at its lowest ebb, while the demand on pilot capabilities is at its greatest. Careful preparation will help you cope with this high workload.

If your aircraft is GPS-equipped, be aware that the GPS is an aid to, not a replacement for, your basic navigational skills. The route indicated by the GPS may be completely inappropriate to operating in mountainous areas – the GPS does not recognise areas of likely turbulence, or which side of a valley is more appropriate to follow, for example. The GPS can distract you from critical heads-up time if you have to operate or interpret it.

Hypoxia

At higher altitudes, lack of oxygen can cause hypoxia. Below 10,000 feet a healthy pilot should not be affected significantly by hypoxia. If the pilot is unwell (or a smoker), they will be more susceptible to hypoxia. Even at heights of 5000 to 8000 feet the brain will generally not work as efficiently as it does at sea level. This is particularly so if there is a difficult and unfamiliar mental task to perform, or a complicated emergency to deal with.

Hypoxia can be very subtle in its onset. The pilot is unlikely to recognise the problem because the brain is not working properly. Obviously this can be very dangerous, especially as the symptoms can result in a feeling of wellbeing combined with a loss of self-assessment, and poor judgement.

In New Zealand, flight between 10,000 and 13,000 feet is allowed for a maximum of 30 minutes without oxygen. If you plan on taking advantage of this, be alert to the dangers of hypoxia. Remember that your passengers may be susceptible to hypoxia at a lower altitude than you.

Other Considerations

We have already mentioned that the likelihood of turbulence is greater in the mountains. Flying in turbulence will add to your fatigue and may possibly nauseate you. Know when to call it quits so you are not left trying to fly while fighting off airsickness.

When flying at altitude the air is drier, so be alert to dehydration on longer flights.

Glare is also greater, as there are less atmospheric pollutants, and reflections occur off cloud and snow-covered terrain. Wearing a good pair of aviation sunglasses is a simple fix for this.

With the cooler air at altitude, the use of cabin heat is more likely. Make a regular check of your carbon monoxide detector to ensure that there are no dangerous gases leaking into the cockpit.

Survival Equipment

The amount of survival equipment you should carry will depend on the number of people on board and the type of terrain you will be flying over.

Make sure you and your passengers bring warm clothing – eg, a warm jacket, gloves and hat – even when flying in summer.

As well as the CAA GAP booklet *Survival*, there are two CAA safety videos that will help you to be prepared for a survival situation. *Survival* covers various aspects of a forced landing in a bush setting and *Mountain Survival* follows a course for professional pilots who operate daily in snow-covered terrain.

The key points to remember are our body's need for air, warmth, hydration, and food. We can survive only a few minutes without air; a few hours without warmth; a few days without water; and a few weeks without food. In addition, we must have the will to survive.

Survival equipment should reflect the need for shelter, warmth, water, food, aiding visibility for searchers, and enhancing the will to survive.

Consider the following possibilities for your survival equipment:

Shelter and Warmth

- A survival blanket (which is fairly cheap and doubles as a reflective surface) or plastic rubbish bag.
- Woollen headgear (a balaclava is excellent) and socks/mittens.
- Waterproof matches, fire starter/fire paste. If wood is wet a small piece of rubber or plastic tubing can be useful.
- Small candles (birthday type are ideal). A soft plastic comb can also produce flame.
- Torch. Light sticks.
- Pocket knife/multi-tool.
- Rope/cord. Duct tape.
- Toilet paper (for comfort and fire-lighting).

Location and Visibility

- Signal mirror.
- Whistle.
- Compass.
- Orange/yellow plastic sheet.

Water

- Water purification tablets.
- Container (billy-style?) to keep everything in – preferably type that can also be used to heat water and food.
- Plastic bags.

Food

- Glucose barley sugars.
- Raisins and chocolate.
- Soup/tea bags/milo.
- Fish hooks and fishing line (for food and passing the time?).

Will to Survive

- Survival handbook.
- Previous knowledge and training will instil confidence.

A Few Pointers from the Professionals

- File a flight plan.
- Study charts carefully for terrain, pass heights, and good reporting points. Prominent peaks make good reporting points.
- Get and use as much weather information as you can. Check winds, especially at altitude.
- The wind will often tend to be a prevailing westerly above 10,000 feet.
- Don't go when upper winds are forecast over 25 knots. Winds will be much stronger over mountain passes.
- Don't go in doubtful weather.
- Always have enough altitude to allow you to glide to a safe landing area.
- Constantly assess the wind direction and logically apply this to your flight path. There can often be abrupt changes to wind direction and speed.
- Finding a useable horizon can be difficult. Visualise where the sky meets the sea and superimpose this horizon on the terrain as if the mountains were transparent.
- Remember the effects of density altitude. Takeoff and climb will take much longer.
- Approach passes and ridges at no greater than a 45-degree angle.
- If you find yourself in a downdraught, keep the nose down to maintain a safe airspeed, and alter your flight path to fly out of the downdraught.
- Fly on one side of the valley, not down the middle. Flying on the lift side will keep you in the upgoing air and provide room to turn around if need be.
- Don't fly any closer than necessary to abrupt changes of terrain. Dangerous turbulence can be expected with high winds due to disruption of the airflow.
- Check QNH at departure point and (if available) at destination. A large differential (say 4 hPa) equates to high winds and turbulence, even if this is not evident on the ground at departure.
- Get as much advice as you can from someone who knows what they are talking about. The local mountain operators would rather spend 15 minutes giving you a briefing on their area of expertise than 15 hours rescuing you.
- Do not fly into mountainous areas when the local pilots won't.
- Get some training before you go. The ranges do not need to be 10,000 feet high, just enough to lose sight of the horizon.
- Fly to your ability and don't be over-enthusiastic. Better to turn back early than attempt it too late.
- Rely on good decision-making, not performance. That is, use your brains and common sense to keep out of trouble rather than rely on aircraft performance to get you out.
- Always anticipate. If you find yourself reacting to cues, rather than anticipating them, then you are strongly advised to seek some specialist mountain flying training.
- Lastly, and most importantly, always have an escape route.

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Mountain Flying was reprinted in March 2012.

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